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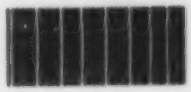

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INSPECTION OF THE ROADCRUISER COACH EQUIPPED WITH A WHEELCHAIR LIFT

Prepared for

TRANSPORTATION DEVELOPMENT CENTRE
Policy and Coordination Group
Transport Canada

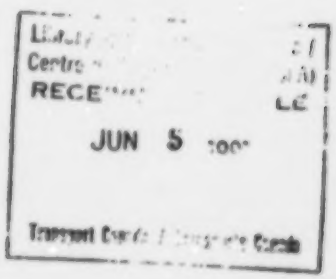
January 1991

By

Ian Voelker, Henry Vietinghoff, Jeffrey Kalibatas

T E S Limited

Kanata, Ontario



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Un sommaire en français de ce rapport est inclus avant la table des matières.

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16. Abstract

This report describes the results of an inspection on an MCI Intercity Bus equipped with a wheelchair lift designed and installed by T E S Limited.

The purpose of the inspection was to determine the condition of the lift and its effect on the structural integrity of the coach after almost six years in service.

The inspection found that the lift was in good condition and functioning properly but required a few minor repairs and adjustments to return it to its original condition. It was found that the addition of the wheelchair lift had not had any adverse effects on the structural integrity of the bus.

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16. Résumé

Le présent rapport contient les résultats de l'inspection d'un autocar MCI équipé d'un dispositif élévateur pour fauteuil roulant conçu, construit et installé par la société T E S Limited.

L'inspection avait pour but de déterminer l'état du dispositif élévateur et son effet sur l'intégrité structurale du véhicule au terme d'environ six ans de service.

On a pu constater que le dispositif élévateur était en bon état et qu'il fonctionnait correctement; il a suffi de quelques réparations et réglages mineurs pour le remettre à neuf. Le dispositif élévateur n'a eu aucun effet sur l'intégrité structurale du véhicule.

17. Mots clés	18. Diffusion
Autocar, dispositif élévateur, durabilité, transports adaptés, personnes handicapées.	Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.

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SUMMARY

A wheelchair accessible bus service has been operated across Newfoundland by CN Roadcruiser since February 1985. The coach, built by MCI, is equipped with a wheelchair lift developed, built and installed by T E S Limited under contract from TDC.

As this lift was the first of its kind in the world and the coach and lift had been in service for almost six years, it was necessary to inspect the coach to determine the condition of the lift and its effect on the structural integrity of the coach.

The coach was brought to the facilities of T E S Limited in Kanata, Ontario for inspection. Structural members in the area where the coach had been modified to adapt the lift were examined for cracks using a liquid penetrant detection method.

No cracks or evidence of deformation were found in the structure. The lift mechanism, which comprises the lifting platform, lift guides, lift actuators and baggage tray, was found to be in good condition with the exception of some minor damage and corrosion.

The hydraulic system which powers the lift actuators was found to be functioning properly. The lift was cycled up and down ten times with the maximum payload of 600 lbs as per SAE D409. No oil leaks, excessive noise, vibration or heat were observed.

The control system which was originally supplied with the lift had been replaced, by CN Roadcruiser, with a new system, as the lift was often not operational due to frequent problems with the sensors on the original system.

The new, simplified system functioned properly; however, it was found that several sensors which indicate system status did not function. As the new system relies on the lift operator to follow proper procedures to ensure the safe use of the lift, it was recommended that CN Roadcruiser review the safety implications of the new control system.

The lift doors were functional, except for damage to the locking mechanism, which was repaired. Corrosion was observed on some components of the latching mechanism and a liberal coating of grease was applied to help prevent its spread. The detent mechanisms on the door hinges were also not functional and were repaired where possible.

The guard rail and safety gate (barricade) were found to be in good condition and the wheelchair and occupant restraints were all functional. One occupant restraint belt was slightly frayed and it was recommended that CN Roadcruiser periodically inspect this belt and the others to ensure that the fraying does not increase.

SOMMAIRE

La compagnie CN Roadcruiser exploite à Terre-Neuve depuis février 1985 un service de transport interurbain accessible aux personnes en fauteuil roulant. L'autocar adapté, construit par la société MCI, est équipé d'une plate-forme élévatrice conçue, construite et installée par T E S Limited aux termes d'un contrat conclu avec le CDT.

Comme il s'agit du premier autocar adapté de ce genre au monde et qu'il est en exploitation depuis presque six ans déjà, il fallait le soumettre à une inspection en vue de déterminer l'état du dispositif élévateur et son effet sur l'intégrité structurale du véhicule.

L'inspection a été faite dans les installations de la T E S Limited à Kanata en Ontario. Les éléments structuraux autour de la cage du dispositif élévateur ont été soumis à un contrôle par ressuage destiné à mettre toutes les fissures en évidence.

Aucune fissure ni aucun signe de déformation n'ont été constatés dans les éléments structuraux. Le mécanisme élévateur, comprenant la plate-forme élévatrice, les guides verticaux, les chaînes de levage et le porte-bagages, est en bon état; il ne présentait que des dommages mineurs et des traces de corrosion.

Le dispositif hydraulique entraînant les chaînes de levage fonctionne correctement. La plate-forme élévatrice a été soumise à un cycle de dix allers et retours avec la charge maximale admissible de 600 lb, conformément aux exigences de la norme SAE D409. On n'a constaté aucune fuite d'huile, ni aucun bruit, vibrations ou dégagement de chaleur indus.

CN Roadcruiser avait remplacé le premier dispositif de commande à cause de défaillances fréquentes des capteurs, qui occasionnaient la mise hors service du dispositif élévateur.

Le nouveau dispositif de commande, moins complexe, fonctionne bien, mais plusieurs des capteurs servant à indiquer l'état du système ne fonctionnent pas. Comme la sécurité du dispositif élévateur dépend de l'opérateur, dans l'état actuel des choses, il a été recommandé que CN Roadcruiser revoie les exigences de sécurité du nouveau dispositif de commande.

Les portes du dispositif élévateur fonctionnent mais le dispositif de verrouillage était endommagé et a dû être réparé. Certains éléments du mécanisme de fermeture portaient des traces de rouille; ils ont été enduits d'une généreuse couche de graisse pour arrêter le processus de corrosion. Les ressorts des charnières ne fonctionnaient pas et ont été réparés lorsque cela était possible.

Le garde-corps et la barrière sont en bon état, et les dispositifs de retenue du passager et du fauteuil roulant fonctionnent correctement. Une des ceintures de sécurité est légèrement usée, et il a été recommandé que CN Roadcruiser procède à une inspection périodique de toutes les ceintures et sangles de sécurité.

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APPENDIX B - Inspection Procedure

1.0 INTRODUCTION

A wheelchair accessible bus service has been operated across Newfoundland by CN Roadcruiser (formerly TerraTransport) since February 1985. The coach used for this service, an MC-9 built by MCI in Winnipeg, was equipped with an internal wheelchair lift designed, constructed and installed by T E S Limited (see Photographs 1 and 2 in Appendix A).

This intercity coach was the first of its kind in the world fitted with an internal wheelchair lift. As this coach has been in service for almost six years, it was necessary to examine the vehicle structural integrity, the wheelchair lift and related components to ensure continued efficient and safe operation of the coach.

This report describes the procedures and results of this inspection, and includes recommendations for future repair and maintenance of the lift and coach.

2.0 INSPECTION PROCEDURES

The coach was returned to the facilities of T E S Limited in Kanata, Ontario so that the inspection could be undertaken in a controlled environment with access to original drawings, other reference material and test equipment.

The inspection was performed by mechanical and electrical engineers who had thoroughly familiarized themselves with the design and operation of the lift system.

Substantial disassembly was conducted to expose structural members and lift mechanisms for inspection. The structural members were examined for cracks using a liquid penetrant detection method. At the same time, the various components of the lift mechanism were inspected for wear and adjustment. After reassembly, the operation of the lift was verified and the bus was returned to Newfoundland (see Appendix B for the inspection procedure).

For reference purposes, a complete description of the lift is contained in a Transport Canada report entitled "Development and Construction of an Elevator-Style Wheelchair Lift for an MC-9 Intercity Coach" (Transport Canada report number TP6674E, T E S Limited report number C580-1).

3.0 RESULTS OF INSPECTION

3.1 Structure

To determine the effect of the addition of the wheelchair lift to the long-term structural integrity of the coach, a close visual inspection was undertaken. This inspection consisted of subjecting structural members in areas of high stress to a dye penetrant (LPI). The inspection focused primarily on the structural modifications which had been done to the frame of the coach to adapt the lifting system.

No cracks were detected during the inspection (see Photographs 3 to 17). As well, no deformation of structural members or evidence of movement of members relative to each other was observed. The latter was partly determined by the fit of the doors and the lift in their respective openings.

3.2 Lift Mechanism

3.2.1 Lifting Platform

All welds and structural members of the lifting platform were sound and in good condition. The metal trim around the edge of the platform floor was lifting in one corner and the screws, which hold it in place, were torn out of the plywood base of the floor. The rubber mat on top of the plywood was in good condition (see Photographs 18 and 19).

The ramp for allowing the wheelchairs to be rolled onto the platform functioned properly; however, one side of the ramp was slightly loose when latched in the vertical storage position. The non-skid surface of the ramp was in reasonable condition (see Photograph 20).

The connection (spherical rod bearings) of the hydraulic lifting cylinders to the platform had corroded to the extent that the spherical bearings could no longer pivot. This does not affect the functionality of the lift actuators but could result in more rapid wear of the lift actuators due to the additional stress. Maintenance of the lift should include a regular application of light machine oil or grease to the exposed bearing surface to help prevent this corrosion from spreading (see Photograph 21).

3.2.2 Lift Guides

The lift guides were examined and appear to be in good condition with no corrosion (see Photographs 22 and 23).

3.2.3 *Lift Actuators*

To verify the operation of the lift, the lift was monitored while raising and lowering various loads. These loads were no load, a fold-up wheelchair with occupant (≈200 lbs) and maximum load (600 lb load as per SAE D409 (Motor Vehicles for Transportation of Physically Disabled Persons)) (see Photograph 24).

In all cases the lift functioned properly; however, some vibration was observed in the lift at the beginning of the lift cycle. After cleaning the lift guides, actuator connections, etc., the vibration seemed to lessen considerably.

Inspection of the lift actuators (hydraulic cylinders) revealed that they were in good condition with no scores on the cylinder rods (see Photographs 25 and 26).

3.2.4 *Baggage Tray*

The tray was in good condition other than a small dent, and functioned as intended when the lift was activated.

3.3 Hydraulic System

The inspection of the hydraulic system verified that all components of the system were still in place. No evidence of oil leaks was detected and the hydraulic oil level was found to be within the minimum required. There was no evidence of any serious chaffing of hydraulic hoses or external wear of hydraulic tubing (see Photographs 27 and 28).

The operation of the hydraulic system was tested by having the lift complete ten raise and lower cycles with a 600 lb. payload on the lift. During the test, system pressure was recorded and the unit was monitored for excessive noise, vibration and heat. As well, the system was checked for hydraulic oil leaks.

The hydraulic system functioned properly throughout the trial. No oil leaks, excessive heat or noise was observed. Relief valve cracking pressure was approximately 780 PSI which agrees with the setting of 800 PSI listed in the operating manual.

Operating pressure for lifting the 600 lb. payload was approximately 500 PSI.

The emergency hand pump was tested and functioned properly.

3.4 Control/Safety System

The original computer control box and all its associated electrical interface circuits were replaced prior to this inspection by a new control box of a different design. The reason for this change was that apparently CN Roadcruiser was having difficulty in keeping all the sensors functional. Due to the requirements of the original control system this meant the lift was often not operational.

The hand-held control unit was replaced by a new unit which is simply an on/off switch for raising and lowering the lift and for engaging the lift locks (see Photograph 29). The original unit had, in addition to this, a display to provide system status information and warning and error messages.

The original wiring harness had been retained but was modified at the control box interface and at locations where sensors have been removed from the system. The following list indicates the sensors which were found to be no longer used in the present system.

Sensors Observed to be No Longer Used

- Barricade (safety gate) locked.
- Lift doors locked.
- Wheelchair restrained.
- Seat Belt #2 in use.
- Emergency mode.

As a result of this modified control system, there were some potential safety hazards observed in using the lift. This was because the modified system relied on the driver or lift operator to follow the proper procedures to ensure the safe use of the lift. The original system, on the other hand, would not allow the lift to function unless the proper procedures had taken place. The potential safety hazards were as follows:

1) The barricade did not have to be closed to operate the lift. As a result, if the operator did not use the barricade, an unprotected opening, that an individual could fall into, existed in the floor of the bus when the lift was at ground level.

2) There were only two indicator lights on the control box, which is located inside the electronic/hydraulic enclosure, to indicate that the locks for the lift were fully inserted. There was no control provided to prevent the bus from being driven with the locks not fully inserted. Also, neither indicator light was functional as the sensors were not being properly activated when the locks were fully extended.

3) The lift could move up or down with the lift doors open.

4) The lift was capable of raising even with the ramp deployed.

5) The locks for the lift could operate not only when the lift was at floor position but at any lift position.

6) The parking brake was not locked into position when the lift master switch was activated.

7) The restraint sensor bar, located at the wheelchair position on the lift, has been disconnected. There was nothing to prevent the lift from operating when the wheelchair was locked into position by the wheel lock arms (wheelchair restraints).

8) As the "RESTRAINT INSECURE" lamp was no longer functional, the proper securement of the wheelchair was entirely dependent on the driver.

Visual and Operational Inspection

The present system was examined and operated and the following observations were made:

- Wire coming from retractable cable was not secured (tied down) and could easily be damaged on entry to the lift.
- Connector #1 on the control box did not lock into place mechanically as it should have. Electrically the connection was sound.
- The grommet protecting the wire to the hand control unit interface box had come loose and no longer protected the wire.
- One of the two locking pin engaged sensors was hanging freely by its wires. The other sensor was not being properly activated when the locks were fully extended.
- Both "ASSISTANCE REQUIRED" switches were broken.
- The "LIFT READY", "RESTRAINT INSECURE" and "CHECK HAND UNIT" lamps were no longer functional.
- All other sensors and indicators used in the present system were operating properly.

3.5 Platform Locks

The locking mechanisms were activated and functioned properly. There was no sign of excessive wear; however, a considerable degree of corrosion had taken place on some components. This was probably due to the salty environment the coach was operating in (see Photographs 30 to 33).

The latch on a cover plate for one of the locking actuators was found to be in need of adjustment.

3.6 Doors

Both lift doors were functional; however, the locking mechanism for them was very difficult to fully engage. It was discovered that a portion of the bottom door lip had been damaged (lip bent up) by the lift, thereby preventing the door from fully closing. This in turn made the locking mechanism difficult to actuate. When the door lip was repaired, the locking mechanism functioned properly again. Corrosion was observed on some components of the latching mechanism but had not yet affected the functionality of the latch. A liberal coating of grease on all components was applied to help prevent further corrosion (see Photographs 34 to 36).

The door hinges allowed the doors to hinge properly, however, the detent mechanism on the hinges was no longer functioning. This detent mechanism is meant to hold the door open even when the bus is on a slope or when a wind is present. The detent mechanism was repaired by replacing the roll pins, which had sheared, with dowel pins. The detent mechanism of the lower hinge on the rear-most door could not be repaired due to the extent of corrosion. It may be desirable to replace this hinge at some future date (see Photograph 37).

3.7 Interior

The guard rail about the lifting area was in good condition except that one end was slightly loose. This was resolved by tightening one hold-down screw.

The safety gate (barricade) was inspected and found to be in proper working condition. Some of the vinyl covering on the seat belt pillars or back rests had worn through in places but was generally in good condition (see Photographs 38 to 40).

3.8 Wheelchair and Occupant Restraints

The wheel lock arms were functional; however, the storage clips were inoperative. When inspected, a single bungie cord was being used to hold both wheel lock arms in place. A single storage clip or bracket for each arm is preferred as the coach operator can only deal with one wheel restraint at a time (see Photographs 41 and 42).

One wheel lock arm was missing a plastic slider or spacer which, although it does not affect functionality, may allow the arm to rattle. Three wheel lock arms were missing roll pins which allow for easy adjustment of arm length; however, this feature is probably not used.

The seat belts were all in good condition except the rear lap belt. It is still acceptable for use but has begun to fray at one spot. It would be advisable to check this belt periodically. The connections of the seat belts to the restraints were all in good condition. The connections of the restraints to the frame of the bus were also in good condition.

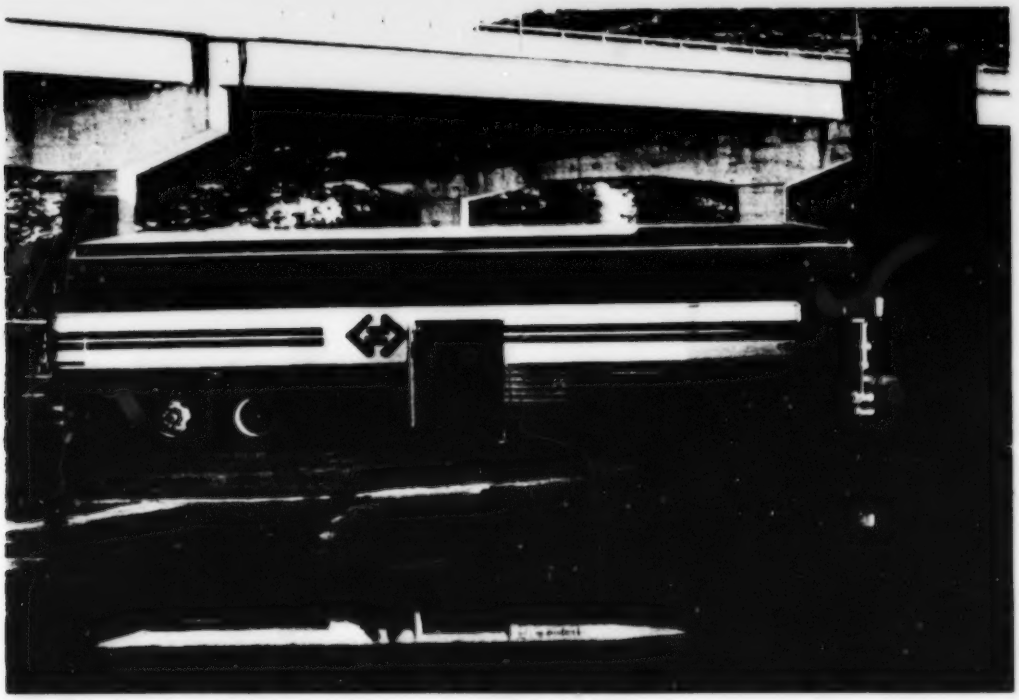
4.0 CONCLUSIONS & RECOMMENDATIONS

Based upon the results of this inspection the structural integrity of the coach has not been adversely affected by the addition of the wheelchair lift. All structural members that have been added to incorporate the lift, and their connections, were sound. The lift mechanism, hydraulic system, platform locks, doors, interior and restraints were all functional; however, a few minor repairs or adjustments were found to be necessary to return them to their original condition. Some of these repairs and adjustments have been done by T E S Limited as stated earlier in this report.

The control/safety system originally supplied had been replaced with a new, simplified system. This system was observed to create some potential safety hazards as it relied almost entirely on the driver/operator of the bus to ensure that safe practices were followed when using or securing the lift and when securing the wheelchair and its occupant. It is recommended that CN Roadcruiser review the safety implications of the new control system and ensure that the drivers are aware of the implications of the change in control system.

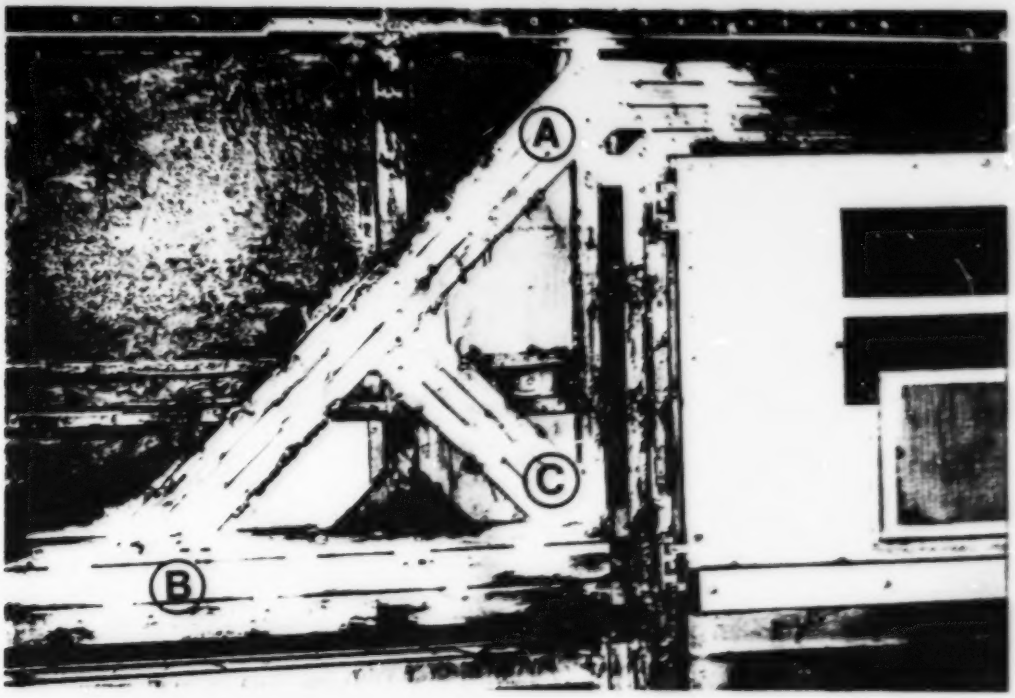
It is also recommended that future maintenance include a periodical inspection of the lap and shoulder belts for the wheelchair occupants, examination and possible replacement of the lower hinge on the rear lift door and lubrication of the spherical bearings where the lift actuators connect to the lift platform.

APPENDIX A
Photographs

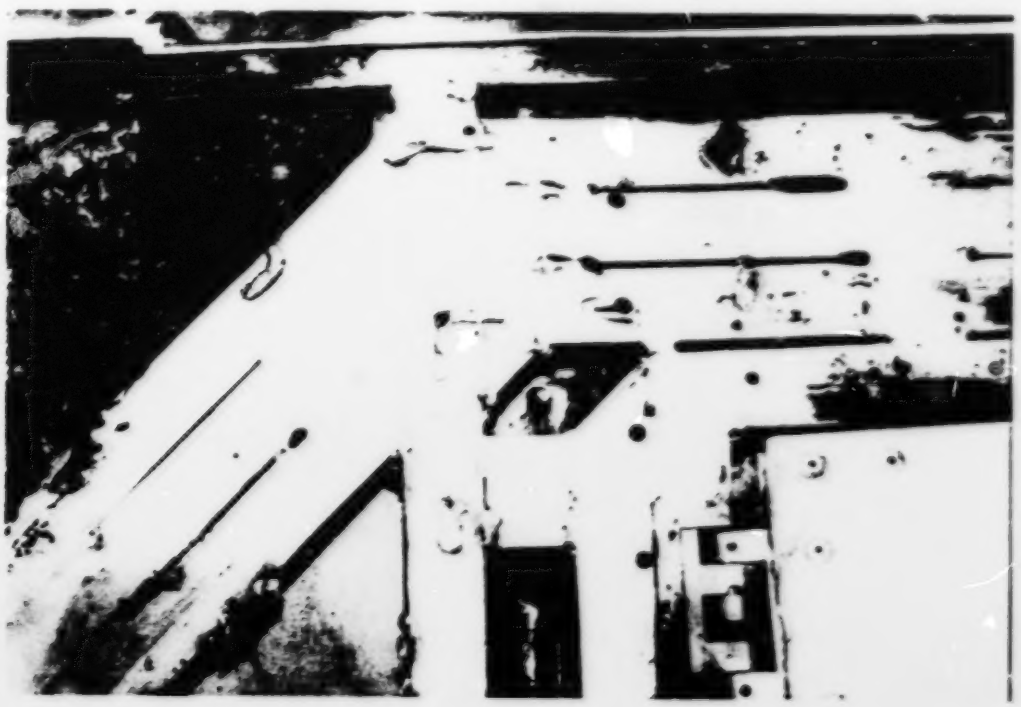


Photograph 1 - TerraTransport Coach Equipped with Wheelchair Lift

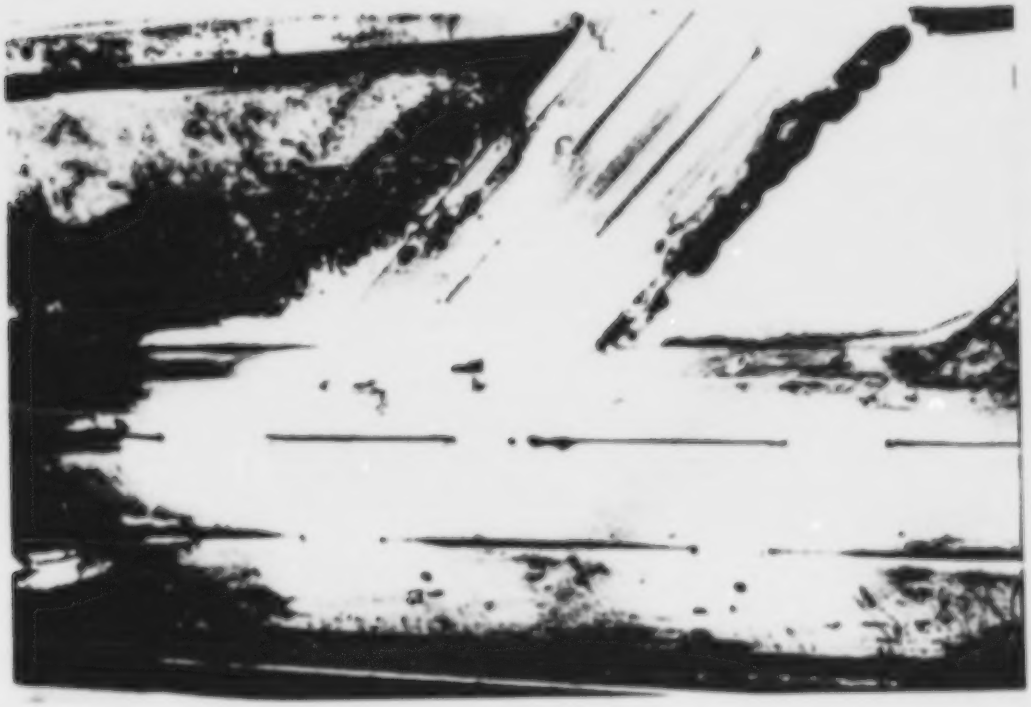
Photograph 2 - Wheelchair Lift



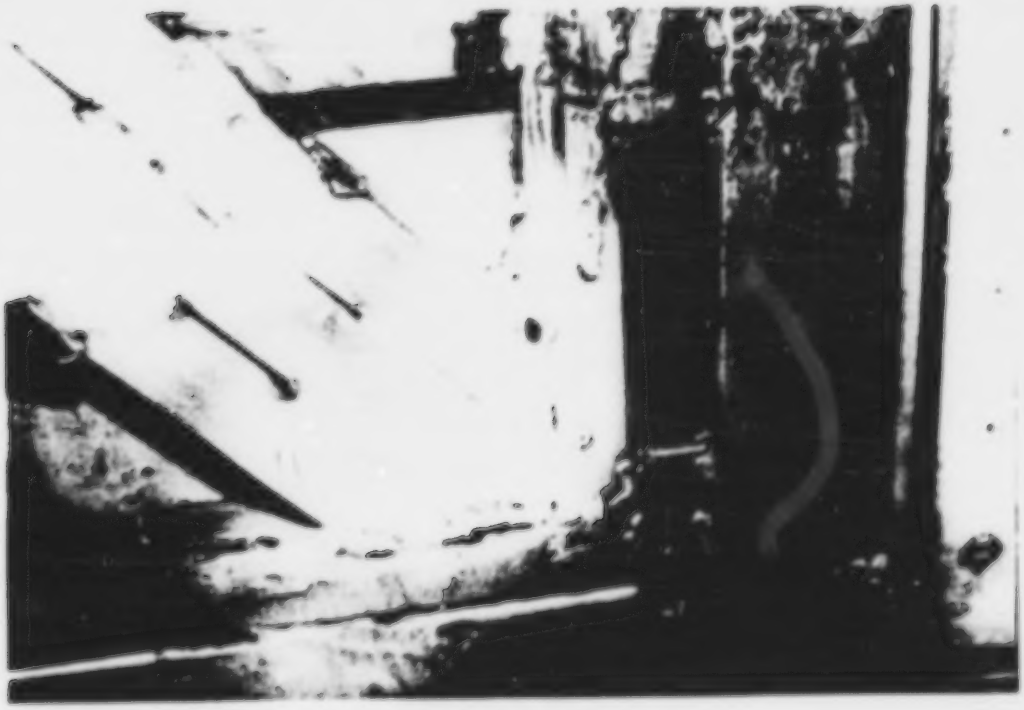
Photograph 3 - Liquid Penetrant Inspection (LPI) of Outer Lift Structure - Rearward of Lift Doors



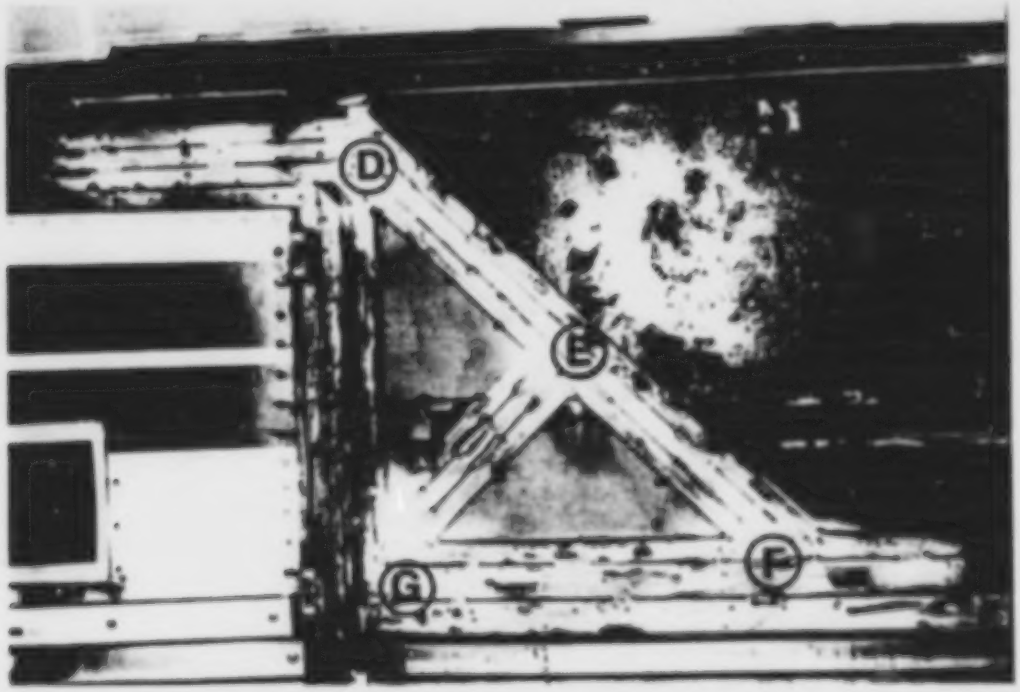
Photograph 4 - Closeup of Joint A



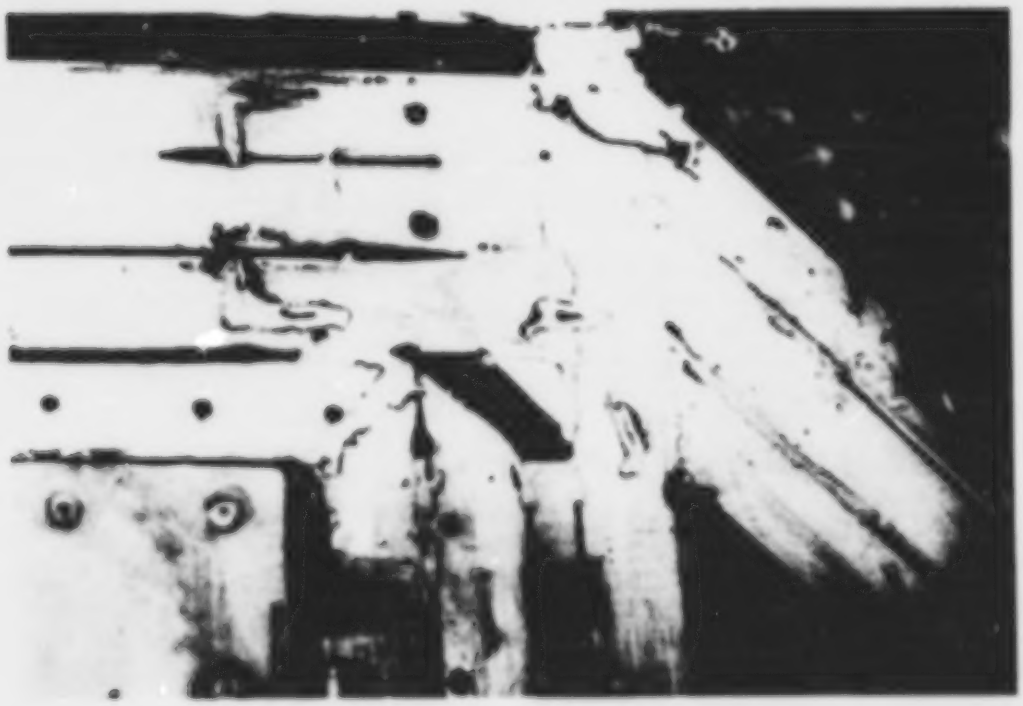
Photograph 5 - Closeup of Joint B



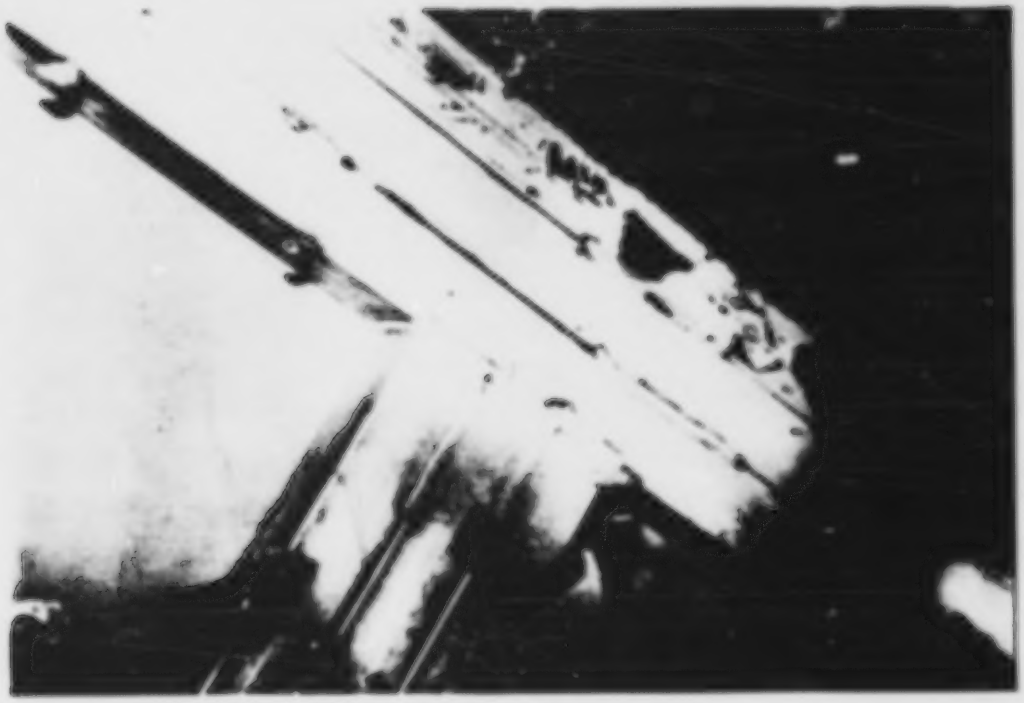
Photograph 6 - Closeup of Joint C



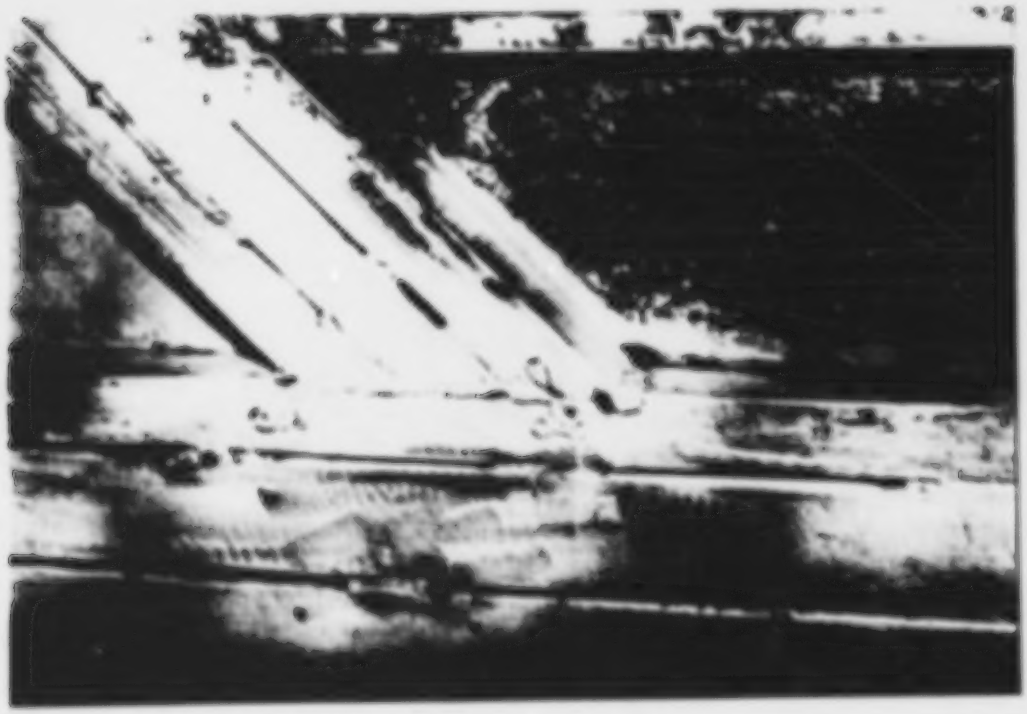
Photograph 7 - LPI of Outer Lift Structure - Forward of Lift Doors



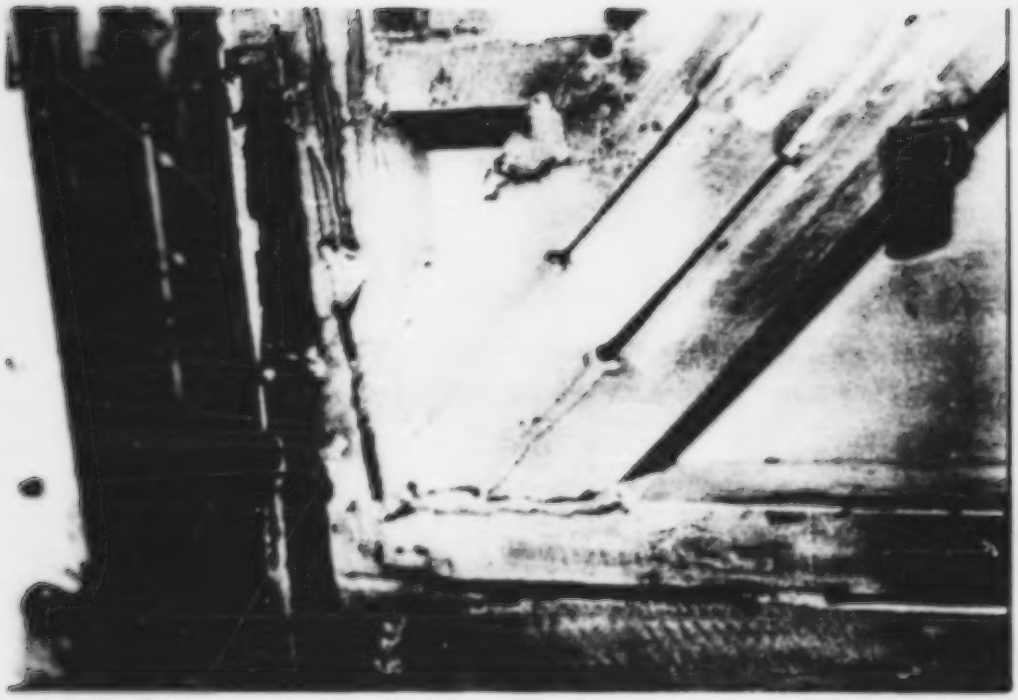
Photograph 8 - Closeup of Joint D



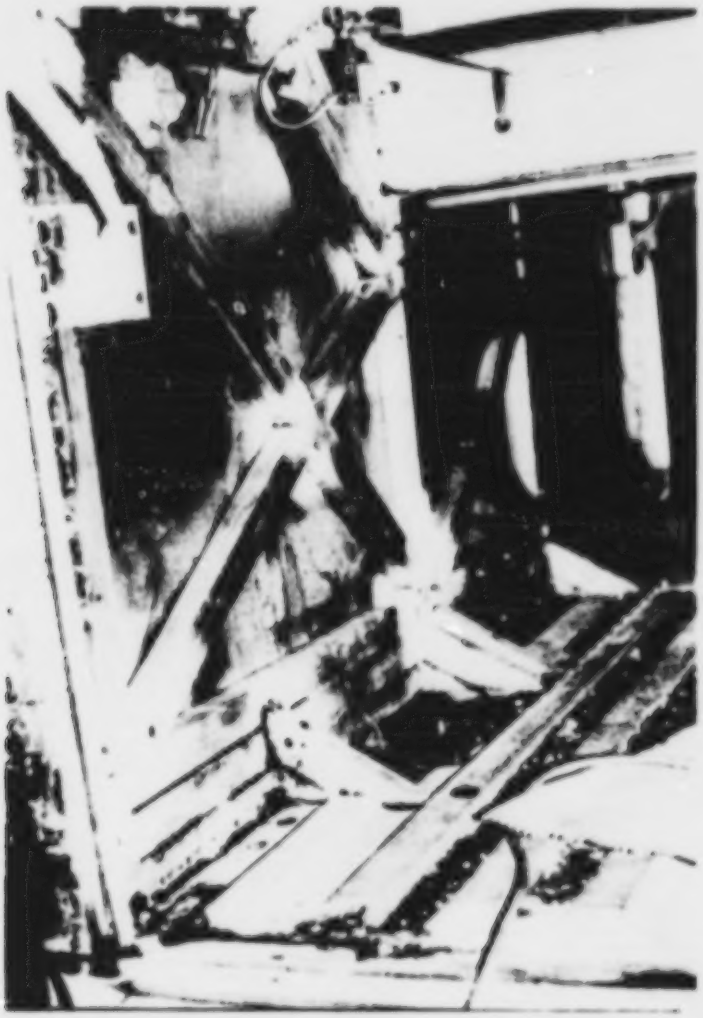
Photograph 9 - Closeup of Joint E



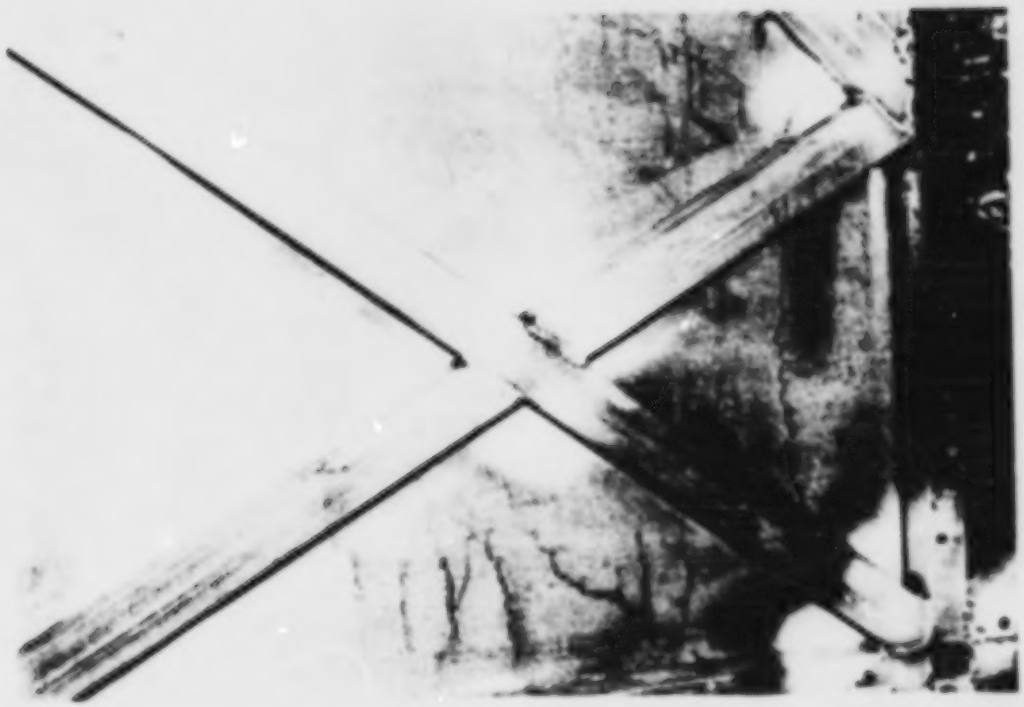
Photograph 10 - Closeup of Joint F



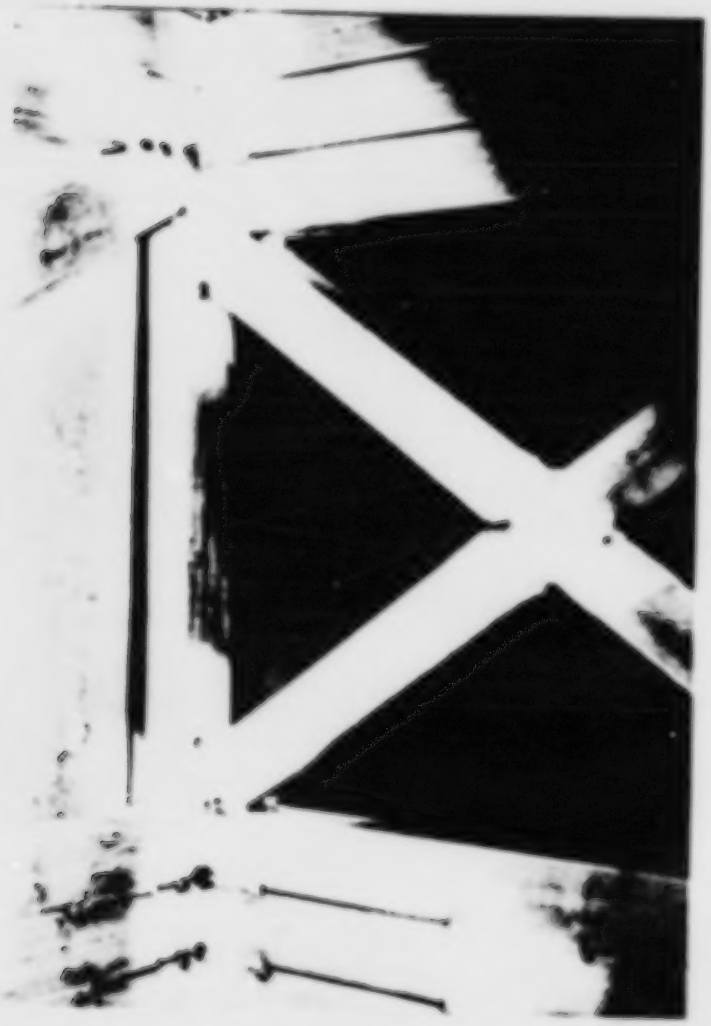
Photograph 11 - Closeup of Joint G



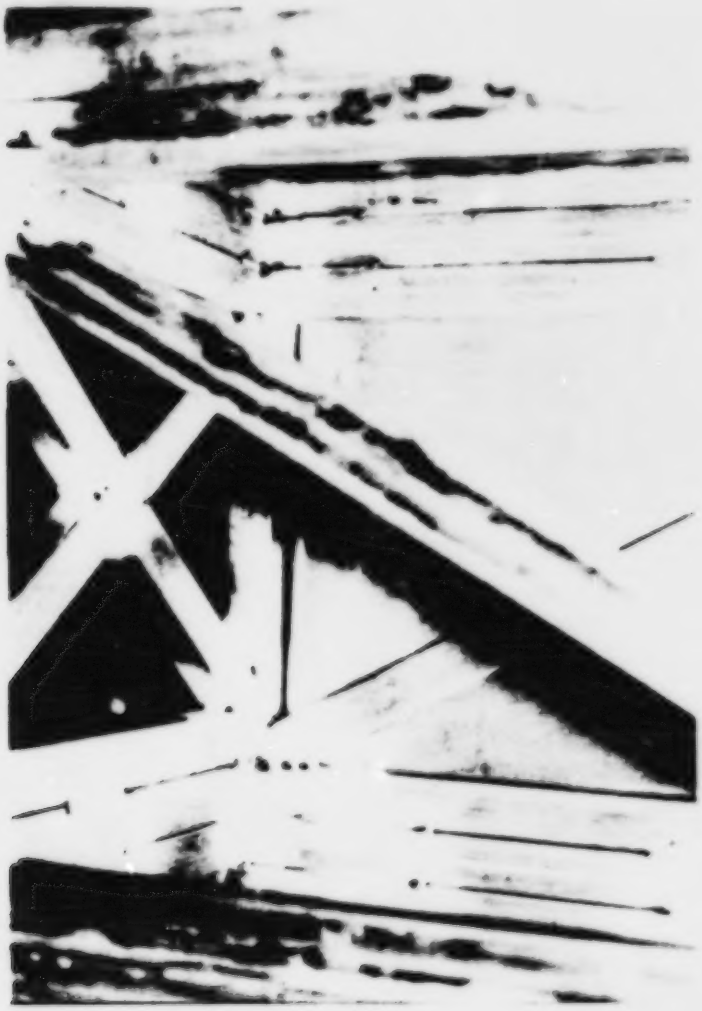
Photograph 12 - LPI of Inner Framework Along Front Side of Lift Well



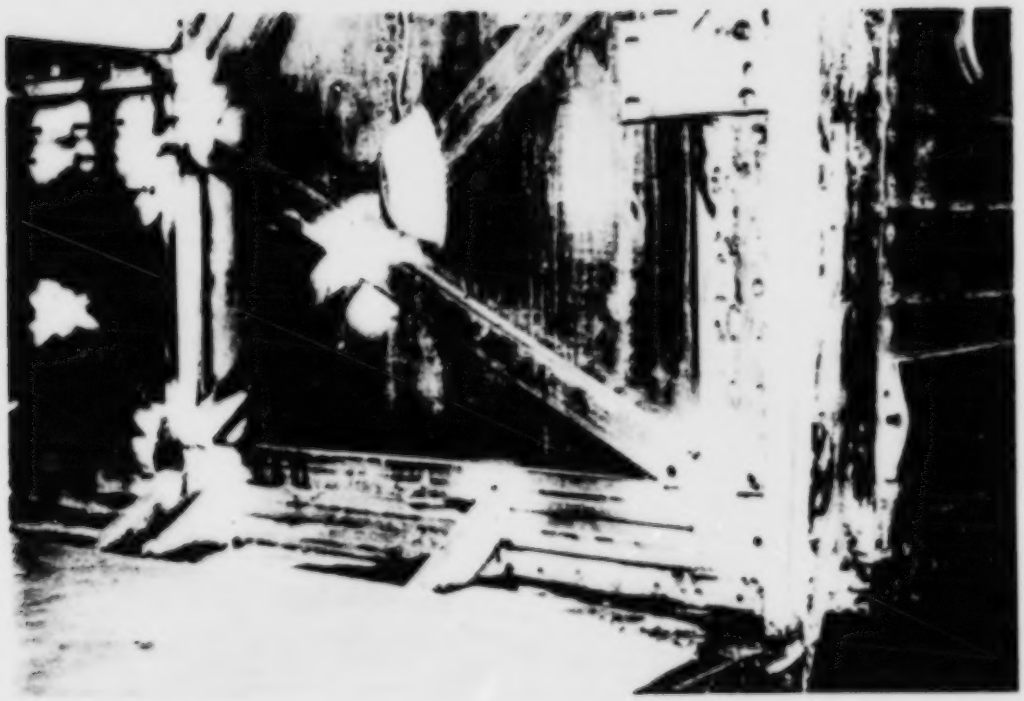
Photograph 13 - Closeup of Photo 12



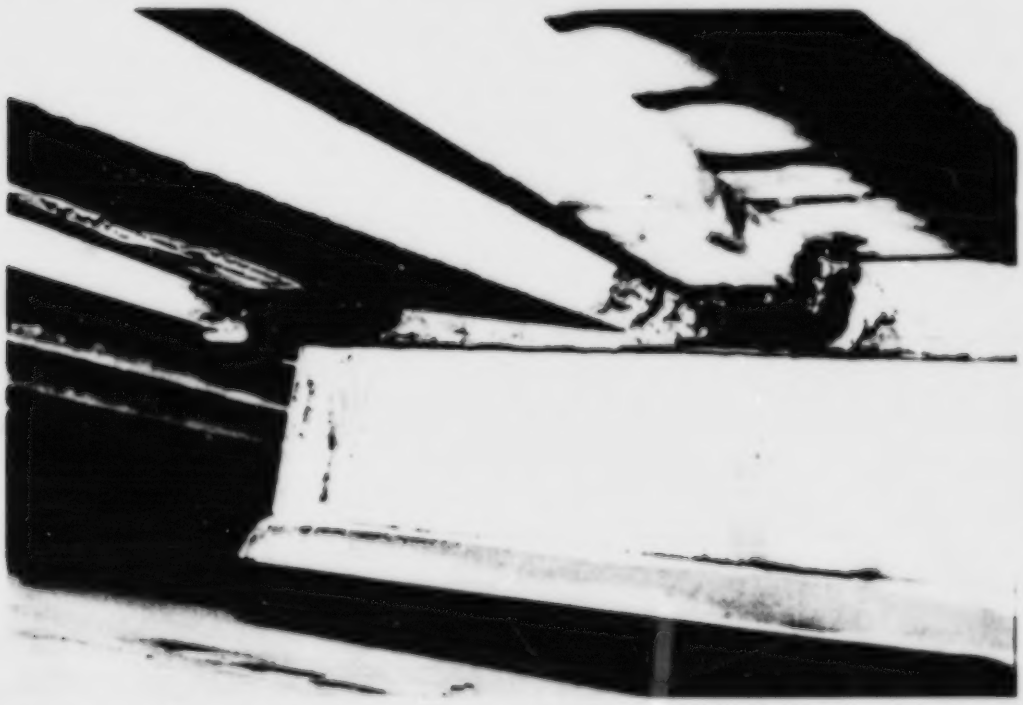
Photograph 14 - LPI of Inner Framework Along Inner Side of Lift Well



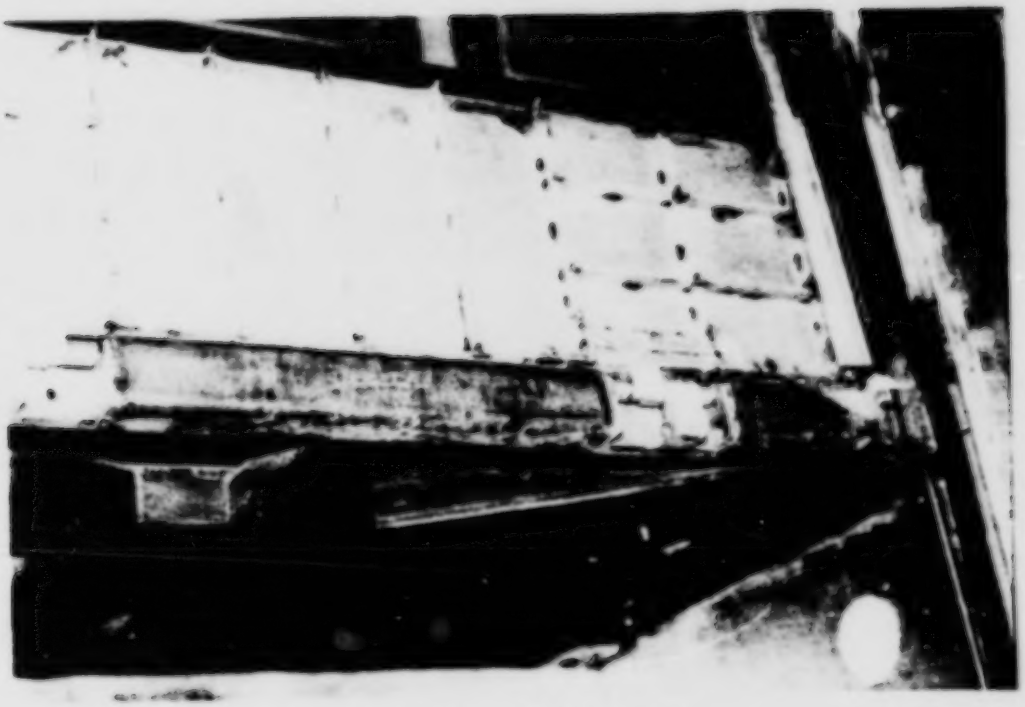
Photograph 15 - LPI of Inner Framework Along Inner Side of Lift Well



Photograph 16 - LPI of Inner Framework Along Rear Side of Lift Well

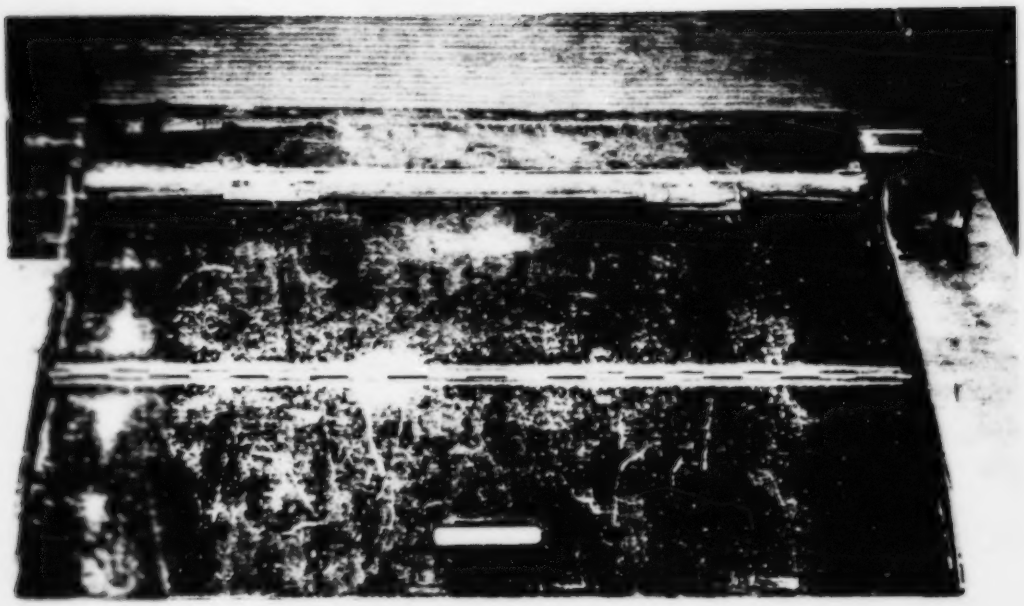


Photograph 17 - LPI of Framework on Underside of Lift Well



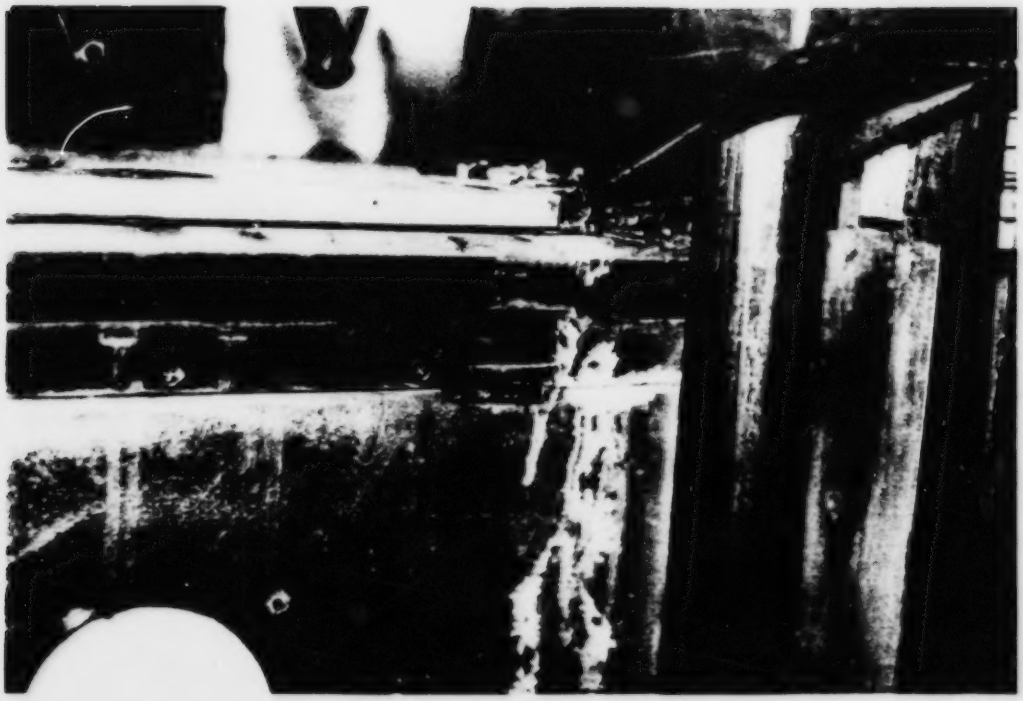
Photograph 18 - Underside of Lift Platform

Photograph 19 - Platform Deck Showing Edge Trim Damage



Photograph 20 - Lift Ramp

Photograph 21 - Cylinder Rod Connection to Lift Platform

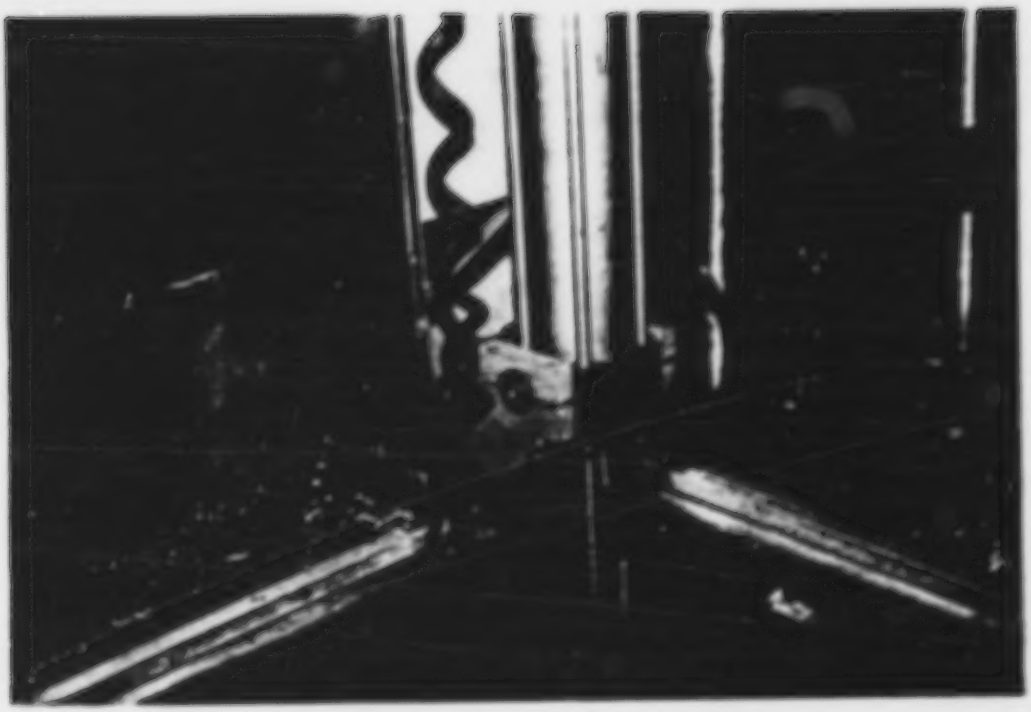


Photograph 22 - Lift Guide

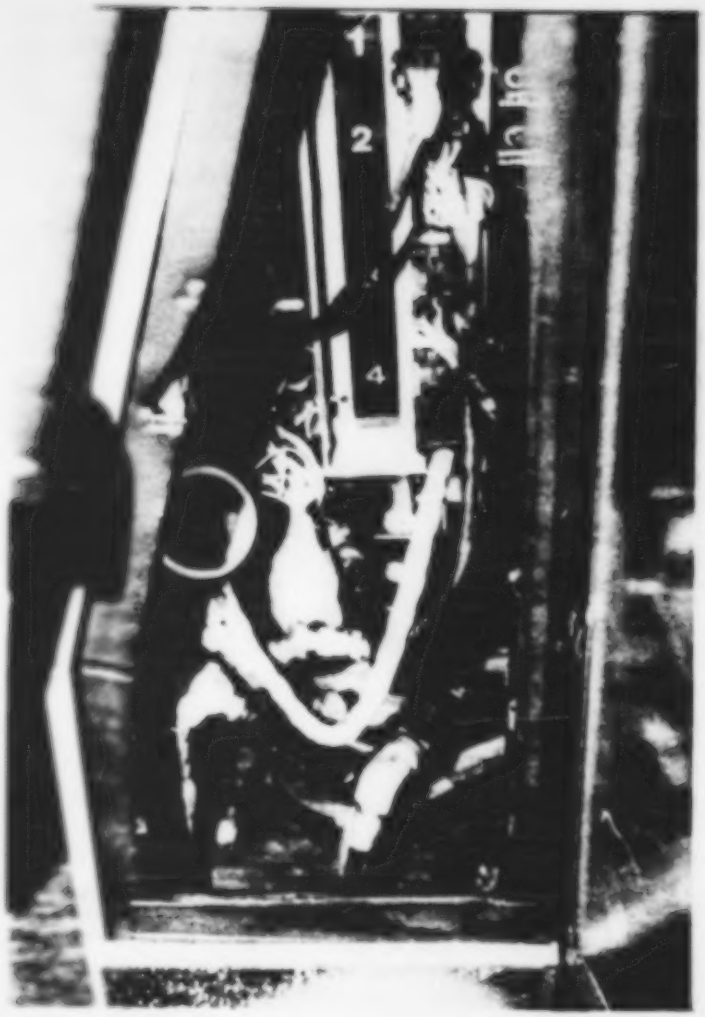
Photograph 23 - Lift Guide Rollers with Cover Assy Removed

Photograph 24 - Lift Test when loaded with 600 lbs.

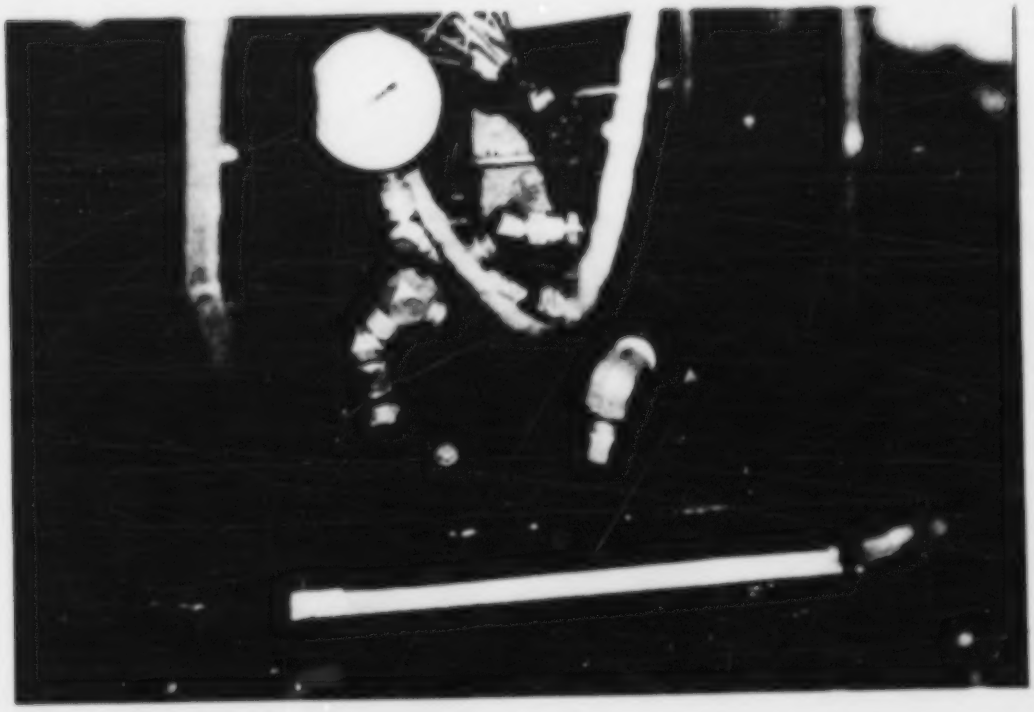
Photograph 25 - Hydraulic Cylinder (Lift Actuator) Shown with Cover Open



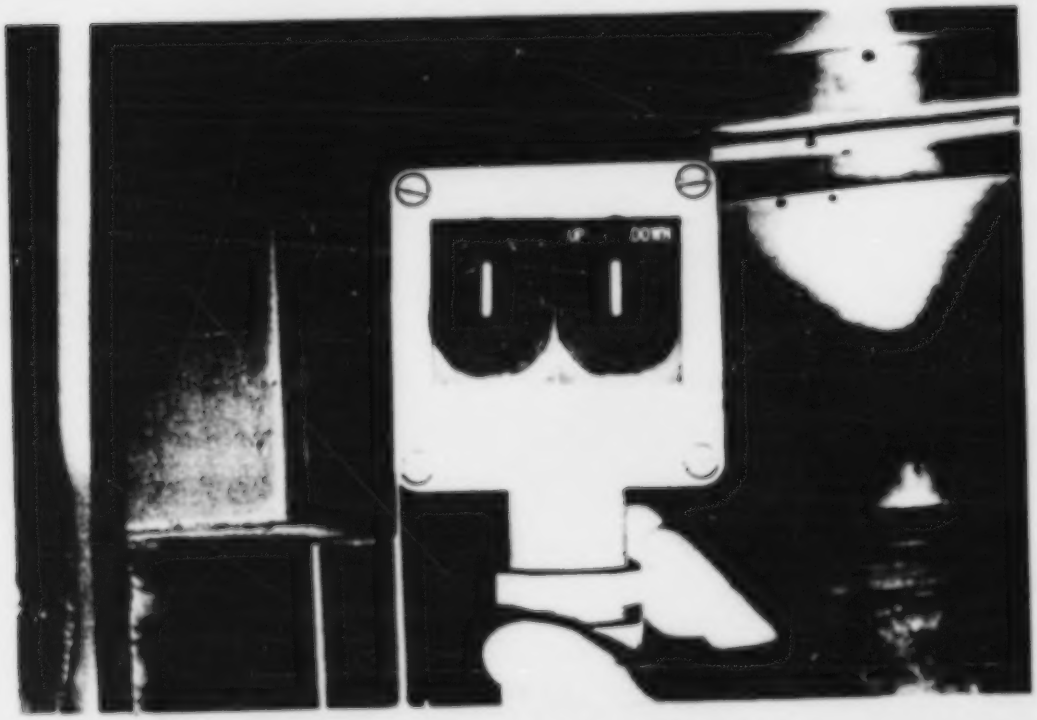
Photograph 26 - Hydraulic Cylinder with Cover Completely Removed



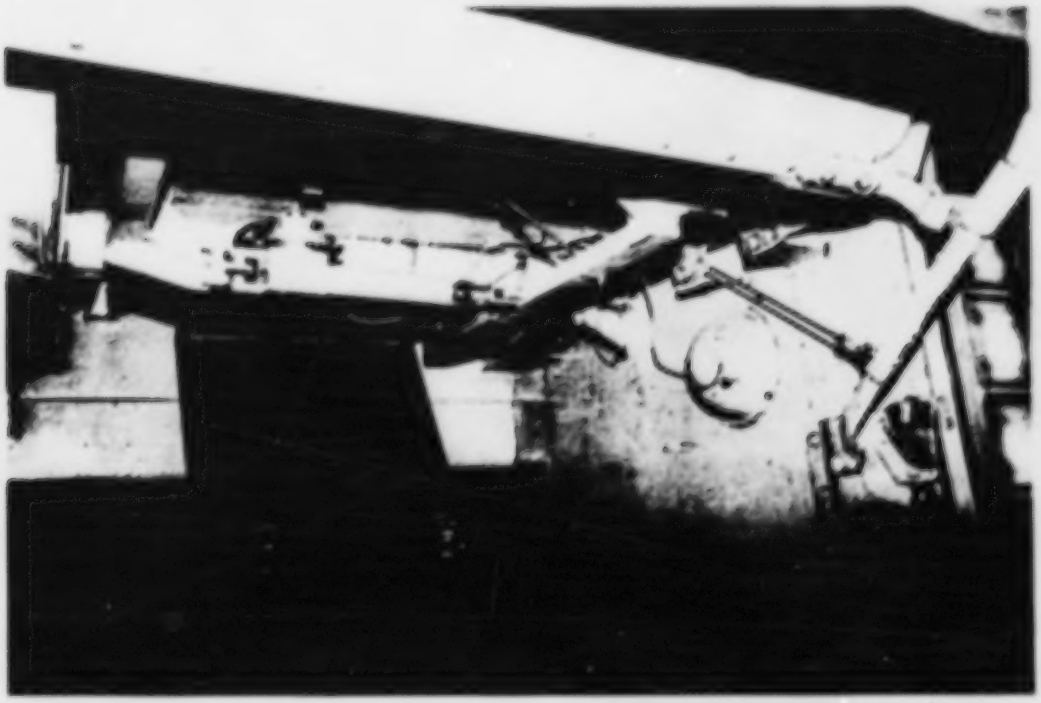
Photograph 27 - Hydraulic Power Supply Compartment
(NOTE: Electronic Control Box)



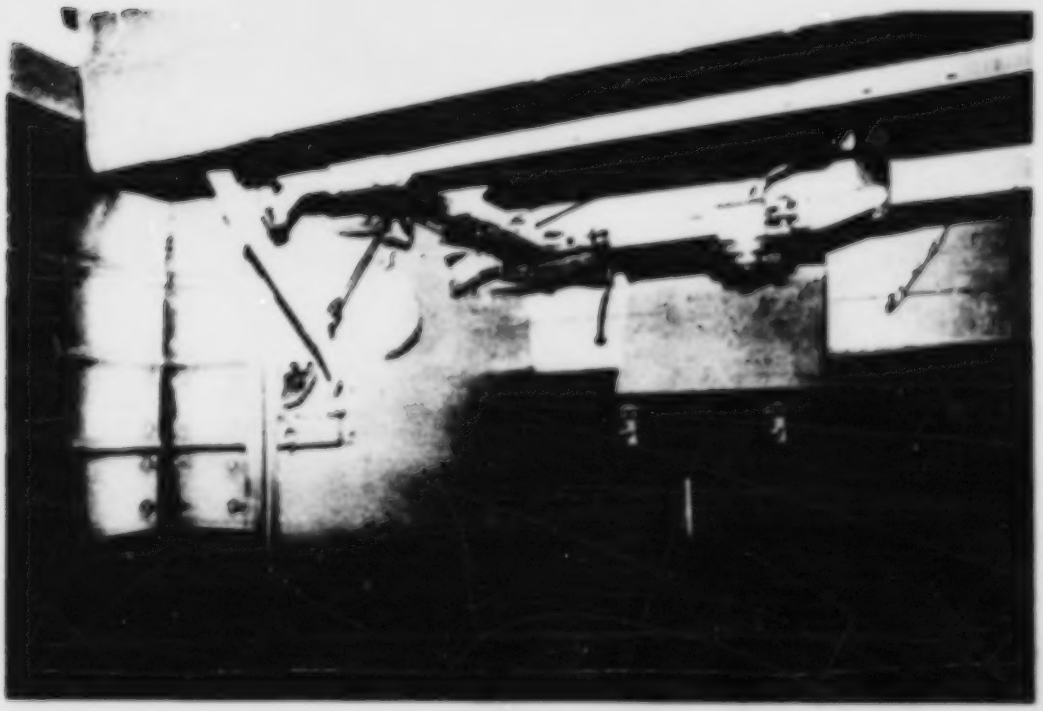
Photograph 28 - Closeup of Floor of Compartment



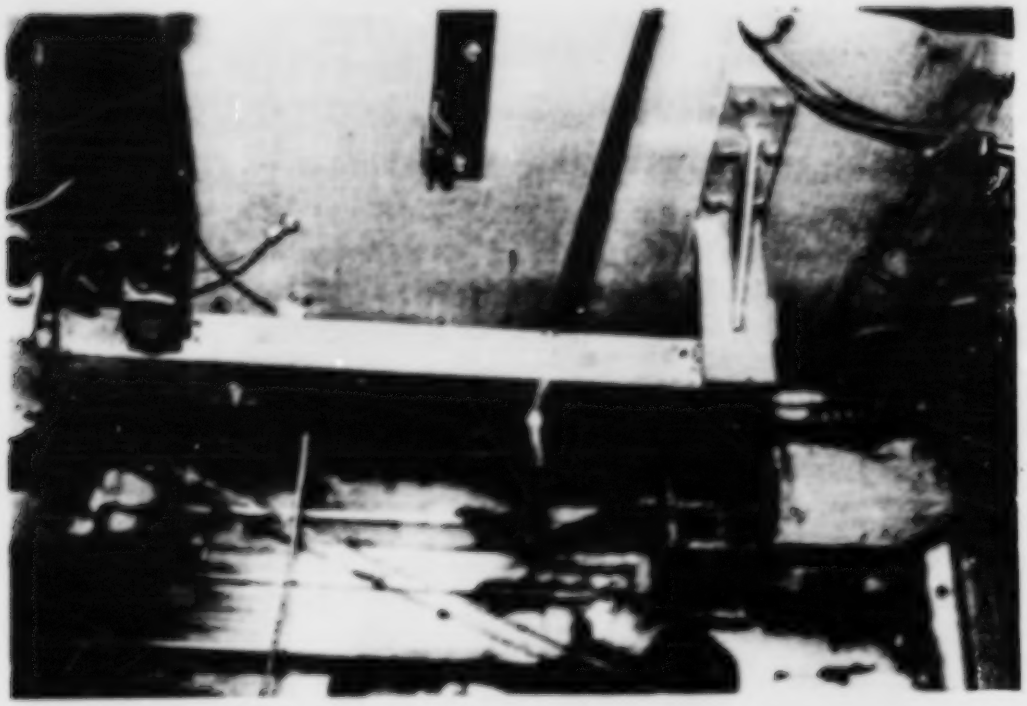
Photograph 29 - New Hand-Held Control Unit



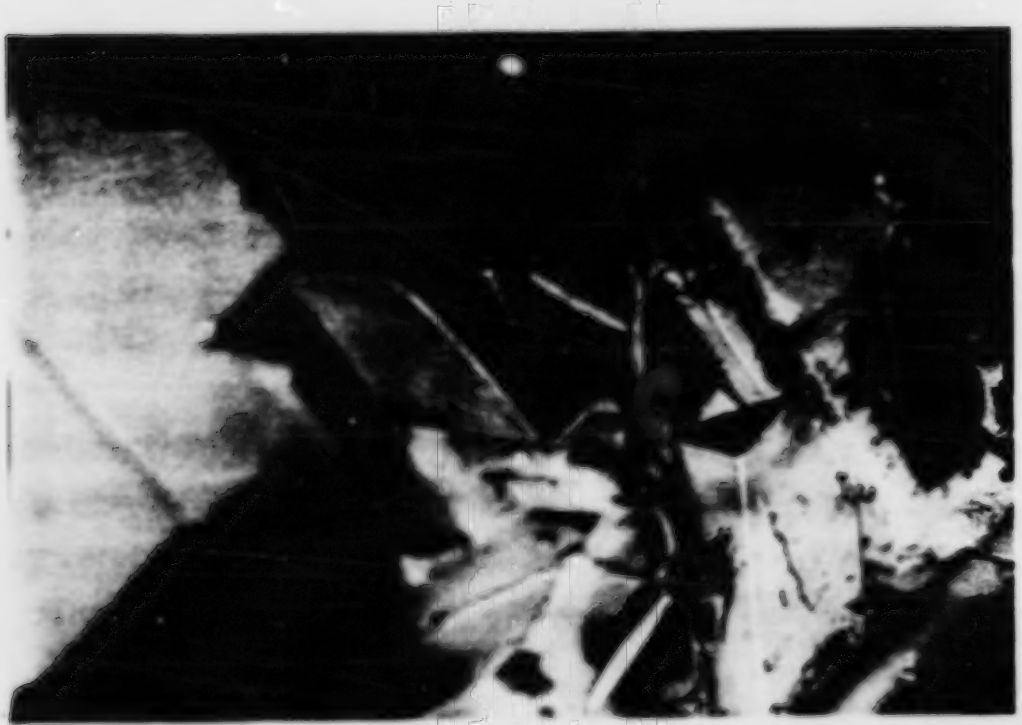
Photograph 30 - Lift Lock Actuator - Rear of Lift Well



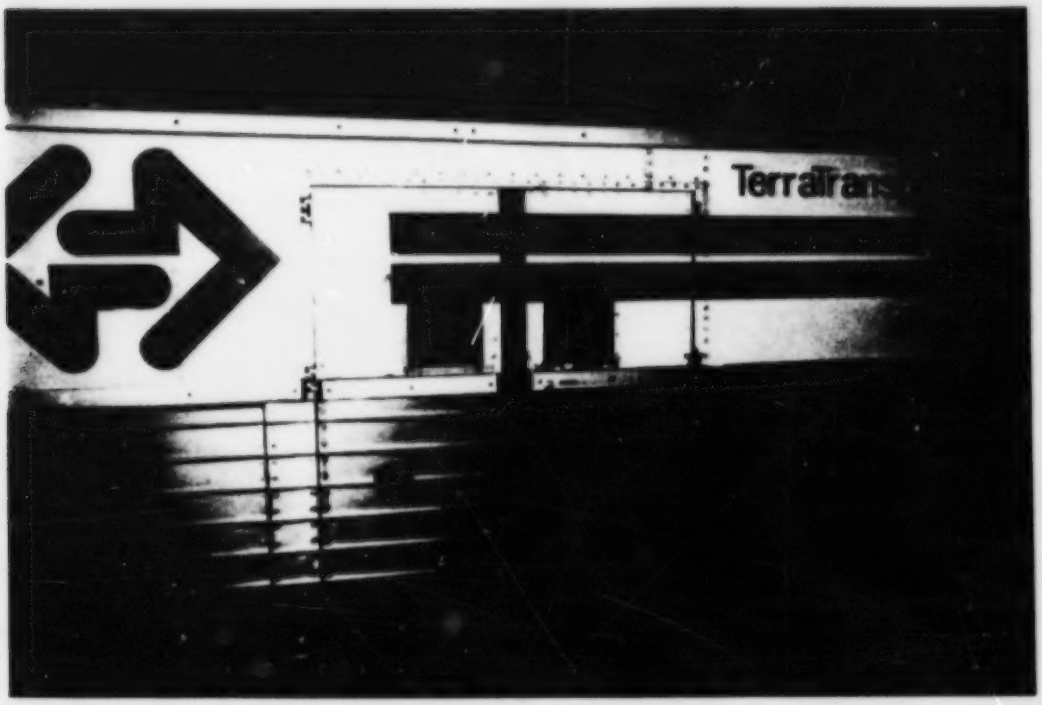
Photograph 31 - Lift Lock Actuator - Forward of Lift Well



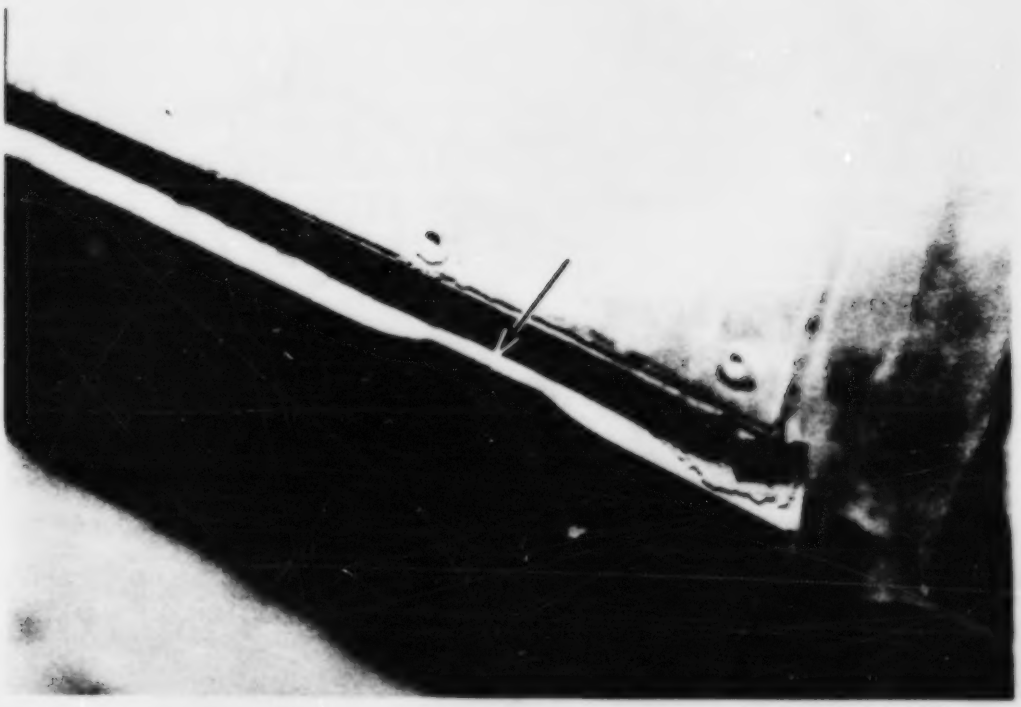
Photograph 32 - Actuator Closeup



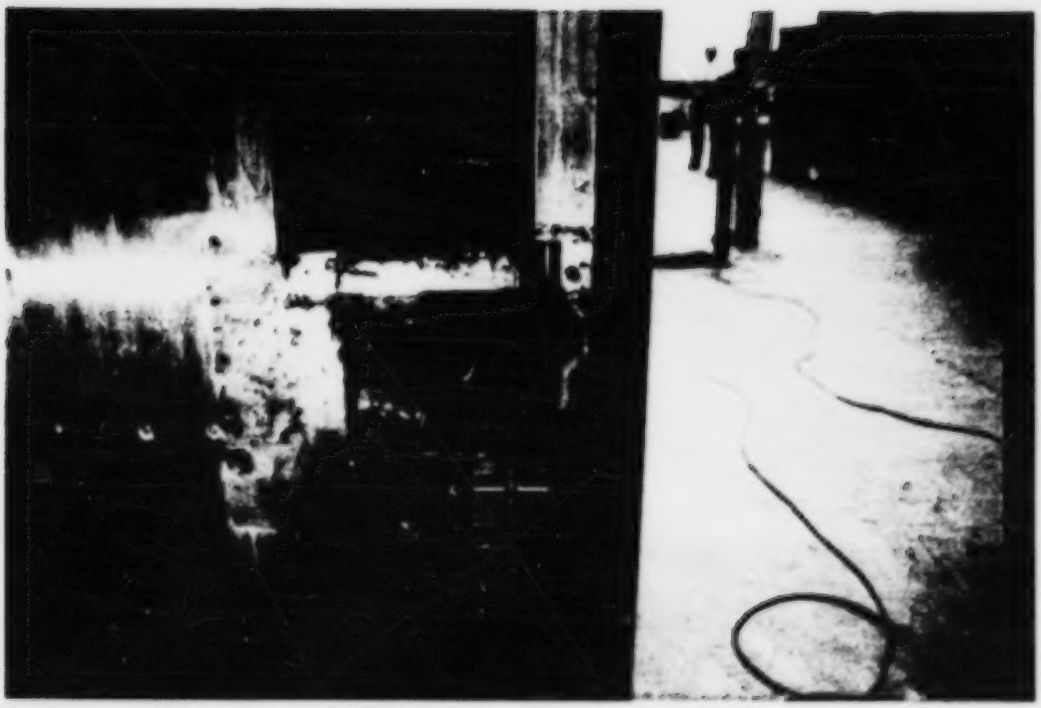
Photograph 33 - Sensor Adjustor - Actuator



Photograph 34 - Lift Doors

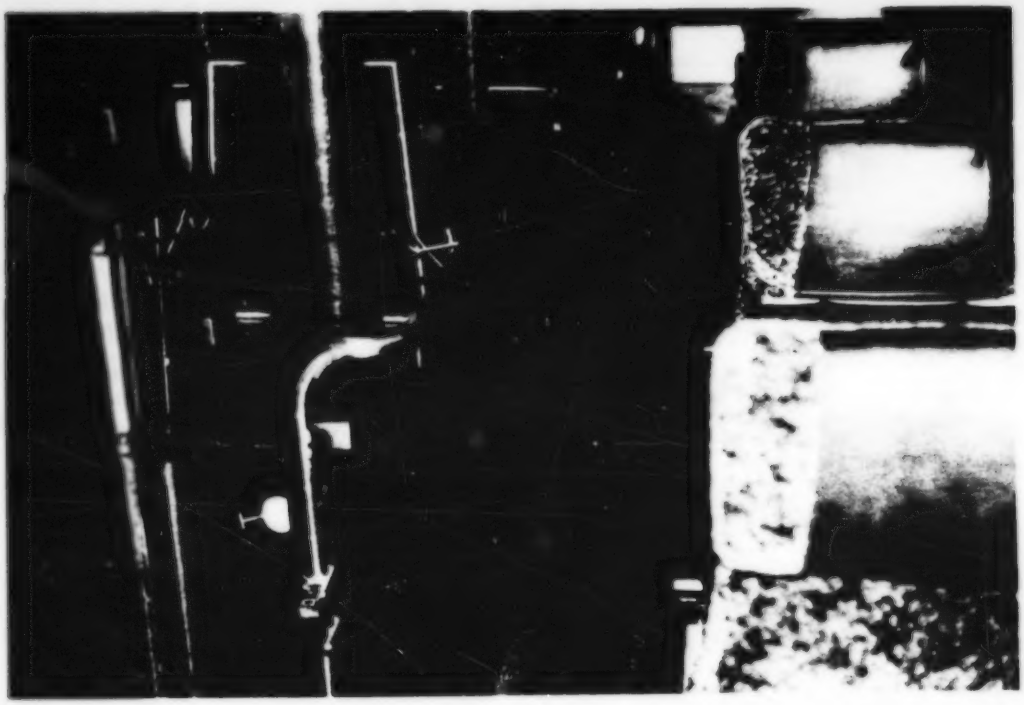


Photograph 35 - Door Lip Damaged by Lift

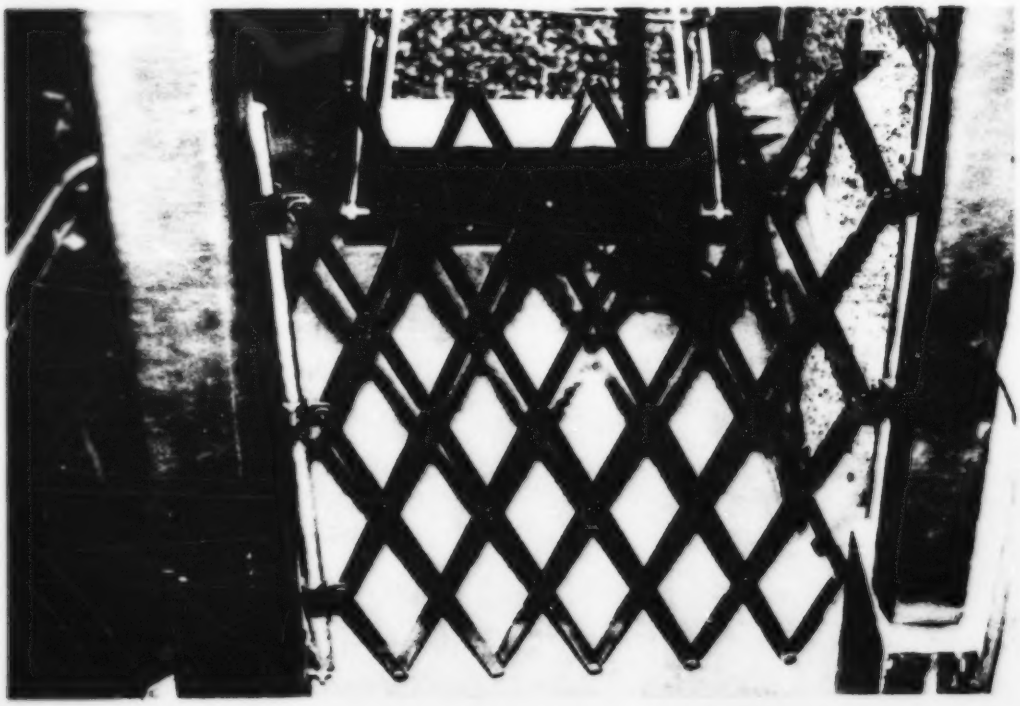


Photograph 36 - Latching Mechanism - Note Corrosion

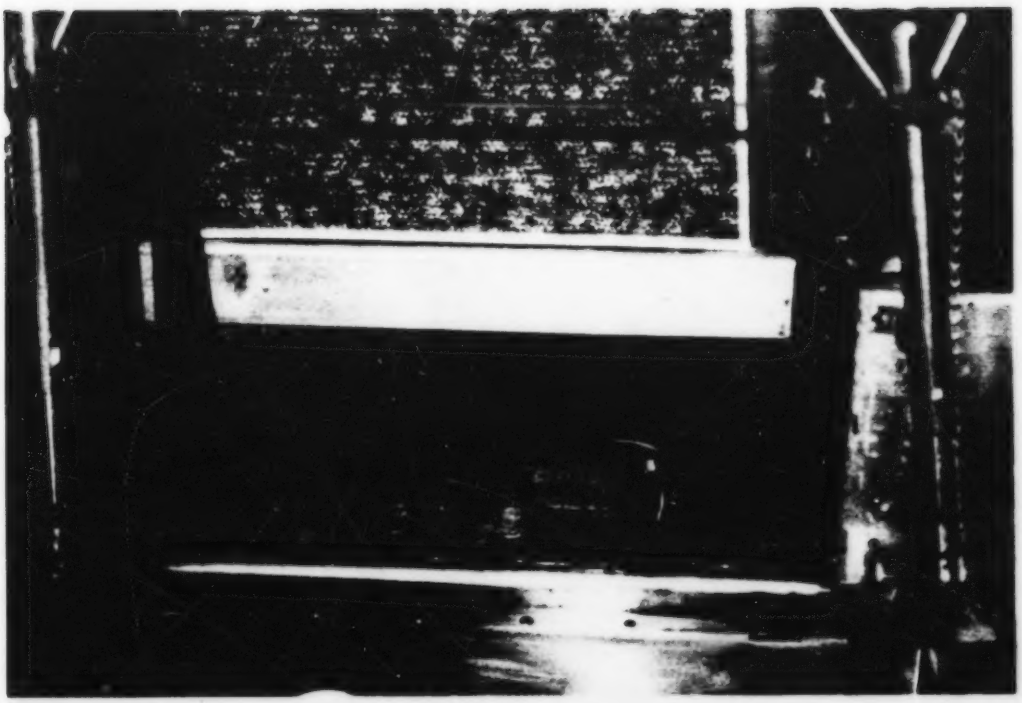
Photograph 37 - Lower Hinge on Rear Lift Door - Note Corrosion



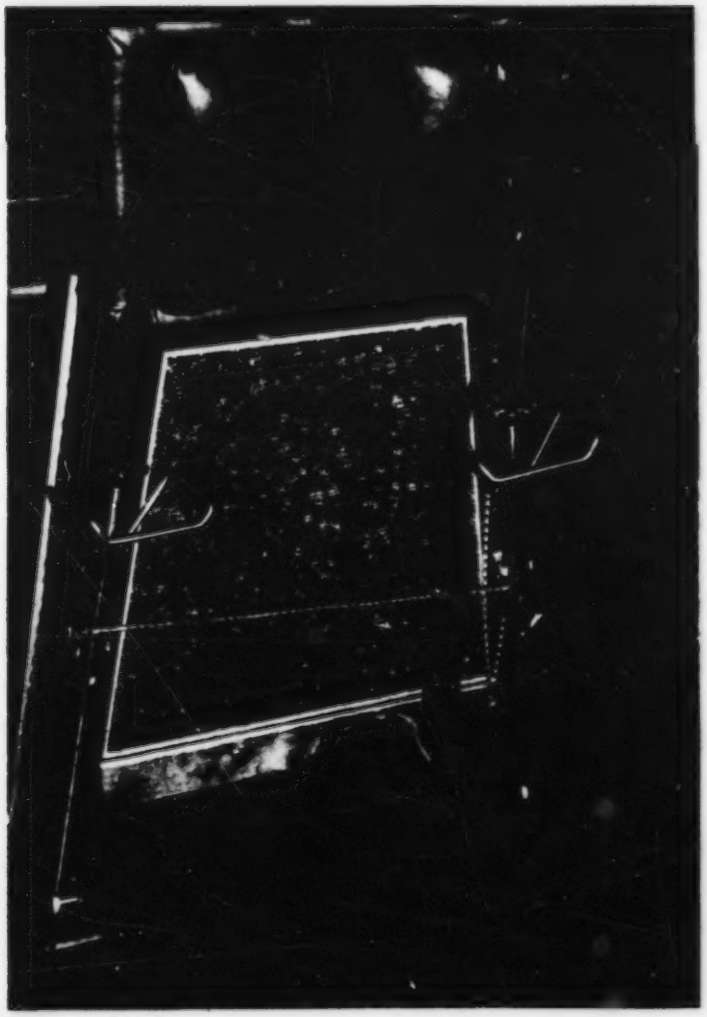
Photograph 38 - Guard Rail Around Lift Well



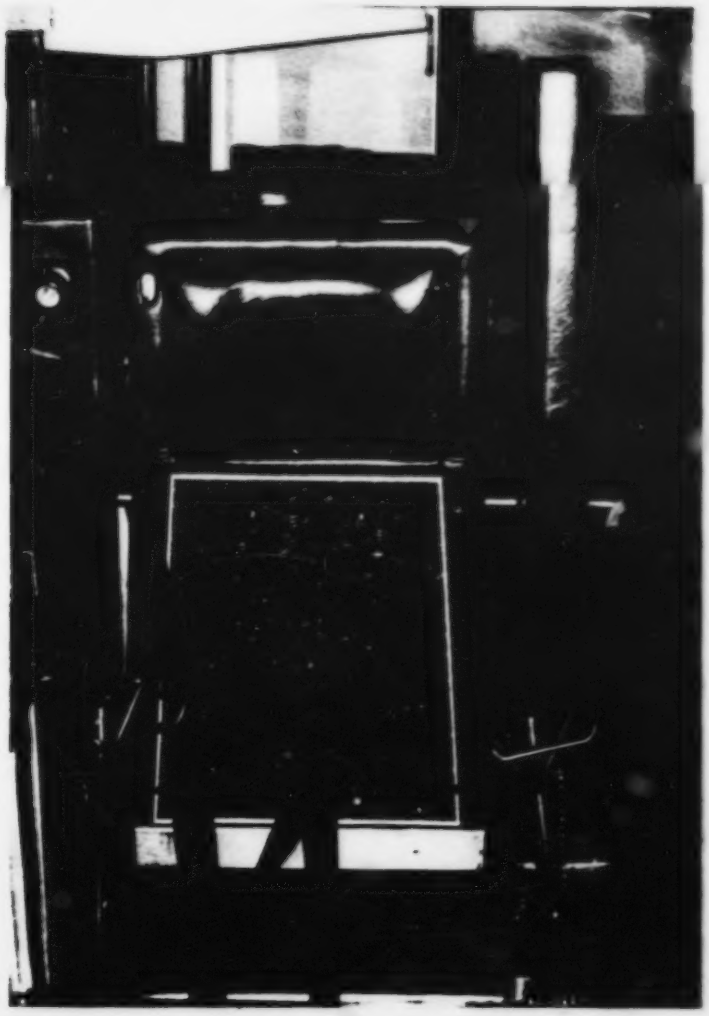
Photograph 39 - Safety Gate (Barricade)



Photograph 40 - Seat Belt Pillars



Photograph 41 - Front Wheelchair Restraints



Photograph 42 - Rear Wheelchair Restraint

APPENDIX B

Inspection Procedure

INSPECTION PROCEDURE

1.0 Structure

- Remove outer skin of bus around lift doors.
- Remove skin in luggage compartment behind and beside lift well.
- Inspect structure for signs of failure, damage or wear.
- Inspect structure for cracks using liquid penetrant inspection methods.
- examine fit of doors and windows around lift area.

2.0 Lift Mechanism

- Inspect upper and lower platform, ramp, shroud and guide rods for damage and wear.
- Operate lift with various loads and observe operation of guide mechanism, lower platform and ramp - all should move without binding and hold position at either end of travel.

3.0 Hydraulic System

- Inspect hydraulic cylinders, lines and hoses for abrasions and leaks.
- Check relief pressure setting of power pack.
- Check fluid level in reservoir.
- Operate lift under load (600 lbs) and monitor system for excessive noise, heat, vibration and leaks.
- Monitor cylinder creep under load.
- Check operation of hand pump.

4.0 Platform Locks

- Inspect actuators and locks for damage and wear.
- Observe operation of locks - both should move without binding and return to retracted position.
- Check adjustment of limit switches.

5.0 Doors

- Inspect doors and door seals for damage and wear.
- Check operation of hinges and latching mechanism.

6.0 Control/Safety System

- Inspect wiring harness for abrasions, cuts, pinching, attachments.
- Inspect micro switches for adjustment, terminal security, mounting.
- Inspect control area for connector, terminal security, wire routing and visible damage.
- Check operation of control system and sensors.

7.0 Interior

- Inspect fixed barricade, folding barricade, guide and hydraulic cylinder covers.
- Operate folding barricade.

8.0 Restraints

- Inspect seatbelts for fraying.
- Check operation of seatbelt buckles, sensor bars and wheel lock arms.